least resistance, while on the northern coast the due south wind is the breeze that has least resistance. However, neither the east nor the south wind is the ideal sea breeze on this coast; it is the southeast wind that predominates. and this breeze finds least resistance at that part of the Texas coast between Baffins Bay and Matagorda Bay, with the greatest known velocities at Corpus Christi.

The physiological effects of this fresh breeze are pronounced. The fresh air of this locality is in marked contrast to some southern sea coasts, where stagnant coditions are frequent. Debilitating calms are relatively few on this coast, while the high-wind movement prevents that dampness and sultriness so dreaded in some subtropical regions.

In conclusion it may be said that the middle Texas coast has the swiftest and steadiest sea breeze to be found on this coast and that the land breeze is not present, except occasionally. This condition is explained by reason of the barren plains that form the hinterland of Corpus Christi, together with the favorable exposure of the place by reason of the curve in the coast line. While this increased sea breeze causes a diminution in the rainfall, it has its compensating features in the fact that a more comfortable climate is thereby created, and sultriness, sweltering heat, and damp conditions are lacking.

DOES THE FORMATION OF ABNORMALLY HEAVY ICE IN THE BERING SEA CAUSE FAMINE IN NORTHERN JAPAN? A REVIEW.

By J. B. KINCER.

Weather Bureau, Washington, D. C., October, 1922.]

By the usual custom of reasoning inductively from cause to effect, the average reader would, perhaps, have considerable difficulty in arriving at an affirmative answer to the above question. Winter scarcity or abundance of ice formation on rivers or large bodies of water concerns the American people chiefly from the viewpoint of personal or commercial convenience during the period of its prevalence and whether or not an adequate supply becomes available for storage purposes in sections where this custom obtains. To the people of Japan, however, the formation of ice in winter in the Bering Sea and neighboring waters has an entirely different and a deeper significance. Its presence in large or small amounts does not inconvenience them in winter nor do they give it a thought for summer use, but it does appear indirectly to largely control their food supply during the following year by the bearing it has on the summer temperatures on which the production of rice, in turn, depends, particularly in the northern portion of the Empire.

Rice is the dominant food crop of Japan. It normally occupies nearly one-half of the total cultivated land, with a value of about twice that of any other crop. The importance of this food to the people is very great, the per capita production being usually about 170 pounds. The high price of land and abundant labor favor an intensive form of cultivation and a product of high quality. Notwithstanding this, there is a large variation in production from year to year, especially in the north, where the summers are normally cooler than farther south. While rice is a tropical cereal thriving best in regions of high temperature and moist air, it is also grown well into the Temperate Zone, but is seldom successfully produced where the mean temperature during the four months of the active growing season is less than 75°. In Japan, however, it is cultivated northward to the 70° summer isotherm.

In this case, as in all others of like nature, where a tropical plant is grown at or near the limits of warmth requirement, the variation of temperature is of great importance, and usually determines in large measure the quantity production.

As an indication of the large variation of rice production in northern Japan, it may be mentioned that the standard deviation in yield in Hokkaido for the period from 1892–1919 was 32 per cent of the mean, expressed in koku per tan, corresponding in comparison to about 12 per cent in the production of corn in bushels per acre in our own State of Ohio. (One koku per tan is equal to about 2.1 American bushels per acre.) In recent times northern Japan had abnormally cool summers in 1902, 1905, and 1913, and in consequence these years saw great rice failures, with resulting very severe famine in most of that part of the Empire.

Owing to the fact that the prosperity of northern Japan depends so largely on the rice crop grown there and the further fact that rice production is so intimately related to the summer temperature, the question of causes for the variations in temperature has been given exhaustive study by meteorologists in that country. A paper on the subject by Dr. T. Okada, who is well and favorably known to many meteorologists in this country, was published in the *Journal of the Meteorological Society of Japan*, December, 1915, in which the relation of the intensity of the prominent centers of action, embodied in the winter Siberian HIGH and the Aleutian LOW and their counterparts, the summer Pacific anticyclone, and Asiatic depression, to the temperature in Japan was pointed out.[1] Later the same author pointed out the relation between the July temperature of our Pacific coast and that in Japan. He found in this case a negative relation between the temperature at San Francisco, Calif., and Erimo, Japan, represented by a correlation coefficient of -0.51 ± 0.10, when the variations in temperature from one year to the next were used as a basis for the computation. At the same time a rather high correlation was found between the barometric pressure in a number of western countries and the summer temperature in Japan.[2] In a succeeding note, several additional pressure-temperature relations were shown,[3] while there appeared in the *Bulletin of the Central Meteorological Observatory of Japan*, vol. 3, No. 1, 1919, a very interesting paper by Doctor Okada on the probabilities of forecasting by statistical methods the yield of rice in northern Japan from the several relations he had pointed out in his previous papers.

Up to this point Doctor Okada's studies had led to certain more or less definitely established, or suggested, relations between atmospheric conditions in different parts of the world and summer temperatures in Japan, but the meteorological explanation of these appeared rather involved, especially in view of their multiplicity. In a second paper on the possibility of forecasting the summer temperature and the approximate yield of rice in northern Japan, published in the *Memoires of the*

[1] This article was reprinted in the MO. WEATHER REV., January, 1916, 44: 17-21.
[2] MO. WEATHER REV., May, 1917, 45: 238-240.
[3] MO. WEATHER REV., November, 1917, 45: 535-538.

Imperial Marine Observatory,[4] which has just reached the Weather Bureau library, Doctor Okada has presented some very interesting conclusions.

Two distinct ocean currents bathe the eastern shores of Japan—the northern, or cold, current, "Oyashiwo," and the warm, southern current called "Kuroshiwo," or Japan Current. From observational and other data available it now appears that the summer temperature in northern Japan depends largely on the temperature of the former, "Oyashiwo," flowing southwestward from the Bering Sea and neighboring waters. It was but natural to assume that with abundant ice in the northern waters, which feed this current, it would be cooler in the summer season than when scanty ice prevailed there. But this assumption was difficult to verify because of the lack of ice data from the north. In this emergency, Doctor Okada took the winter temperature at Nemuro in northern Japan as an index of the winter temperatures farther north and correlated these with the yield of rice in northern Japan for the 28-year period from 1892–1919. He found a parallellism represented by the correlation coefficient $+0.55 \pm 0.09$. In view of the length of the period covered and the admitted inadequacy of the temperature data utilized, this shows a remarkably close relation.

Next, the cause of the occurrence of severe and mild winters in the Bering Sea was investigated. He states on this subject:

> As is well known, the winter temperature of the northern waters is chiefly controlled by the inflow of cold air from eastern Siberia, which is a member of the system of cyclonic circulations around the semi-permanent "low" over the Aleutian Islands. It may be supposed that in the year in which the activity of the Aleutian "low" is increased the inflow of cold air toward the Bering Sea and its neighborhoods becomes vigorous and, therefore, there the winter temperature becomes abnormally low. Again, we may suppose that in the year in which the activity of the Aleutian "low" is decreased, the winter of the northern waters is rather mild.

In the absence of observational data as to variations in the intensity of the Aleutian LOW from year to year, Dr. Okada again resorted to the best substitute available. The activity of the LOW is increased when the water is warmer, or the land is colder, than usual, and consequently he took the air temperature records at Dutch Harbor, Aleutian Islands, as an indication of pressure intensity and corresponding temperature conditions over the more northern waters. As Dutch Harbor is located on the warm side of the Aleutian LOW, it is readily conceivable that its pronounced activity would tend to comparatively high temperature there, with abnormally low temperature over the more northern waters in the cold quadrant of the depression. He correlated the Dutch Harbor temperature with the yield of the rice crop in Hokkaido in northern Japan for the 28-year period mentioned. This gave the significant coefficient of -0.63 ± 0.08. Thus we see that Dr. Okada's investigations point very strongly to an affirmative answer to the question at the head of this review.

[4] Vol. 1, No. 1.

NOTES ON TYPHOONS, WITH CHARTS OF NORMAL AND ABERRANT TRACKS.

By STEPHEN S. VISHER.

[Indiana University, Bloomington, Ind., Oct. 5, 1922.]

INTRODUCTION.

The writer is making a study of the tropical cyclones of the Pacific.[1] Data as to the occurrence of storms in the western portion of the South Pacific and in the southeastern portion of the North Pacific have already been presented in this journal.[2]

In respect to the tropical cyclones in the Far East, there called typhoons, much has been published by others. It was the writer's good fortune to have conferences about typhoons with Director J. Algué, of the Philippine Weather Bureau, with Director T. F. Claxton, of the Royal Observatory at Hongkong, with Director L. Froc, of the Zikawei Observatory, Shanghai, and with Director T. Okada, of the Imperial Marine Observatory, Kobe, Japan. From each of these special students of typhoons copies of publications and maps were obtained, as well as opinions in regard to numerous problems. Although each has studied typhoons for many years, most of their work consists of the plotting of pressure data and the frequent determination of the movement and the changes in the cyclones, with forecasts of future changes, together with the almost hourly issuance of warnings in case a typhoon is threatening. Indeed, each declared that he has almost no time and energy for a quiet study of these complex phenomena and endeavored to encourage the present writer to study typhoons as well as the tropical cyclones of other parts of the Pacific. These kindnesses and encouragements have induced the writer to call attention to the several publications concerning typhoons which have been prepared, often under great difficulties, within the Far East, to make more available some of the data they present and to attempt to contribute a little toward solving some of the problems presented by typhoons.

Annual frequency.—As to the annual frequency of typhoons there is considerable difference of opinion, for a storm which one person considers a true typhoon another may consider not severe enough to be so classed. Then, too, although each observatory attempts to cover the entire region, there is, in fact, a certain amount of specialization. This is frankly recognized by Coronas, who in his Climate and Weather of the Philippines, 1903–1918,[3] attempts to list only the typhoons which noticeably affected the weather of the Philippines. However, several lists of typhoons purport to be complete for the entire Far East. The variation in the annual number of typhoons reported by different authorities for certain years is shown in Table 1.

[1] The field investigations were financed by Yale and Indiana Universities and by the Bishop Museum of Honolulu.

[2] Tropical Cyclones in Australia and the South Pacific and Indian Oceans, MO. WEATHER REV., 1922, 50: 288–295; and Tropical Cyclones in the Northeast Pacific between Hawaii and Mexico, ibid, 295–297, 1922.

[3] Government printer, Manila, 1920.